AD-A088 843 DEFENSE NUCLEAR AGENCY WASHINGTON DC F/G 16/3
REENTRY VEHICLE FRATRICIDE CONSTRAINTS ON ATTACK PLANNING.(U)
JAN 78 J F MOULTON
UNCLASSIFIED DNA-5012D SBIE-AD-E300 898 NL

1 OF 1
AD
A088843

END
DATE
FILMED
10-80
DTIC

(12) LEVEL II

AD-E300898

AD A088843

DNA 5012D

REENTRY VEHICLE FRATRICIDE CONSTRAINTS ON ATTACK PLANNING

J. F. Moulton, Jr.
Defense Nuclear Agency
Aerospace Systems Division
Washington, D.C. 20305

20 January 1978

In-House Report

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

THIS WORK SPONSORED BY THE DEFENSE NUCLEAR AGENCY UNDER SUBTASK N99QAXAA12848.

Prepared for
Director
DEFENSE NUCLEAR AGENCY
Washington, D. C. 20305

Destroy this report when it is no longer needed. Do not return to sender.

PLEASE NOTIFY THE DEFENSE NUCLEAR AGENCY, ATTN: STTI, WASHINGTON, D.C. 20305, IF YOUR ADDRESS IS INCORRECT, IF YOU WISH TO BE DELETED FROM THE DISTRIBUTION LIST, OR IF THE ADDRESSEE IS NO LONGER EMPLOYED BY YOUR ORGANIZATION.

A/SBIE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)* (19) AD-E300 898

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER (14) DNA-5012D ✓

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle) (6) REENTRY VEHICLE FRATRICIDE CONSTRAINTS ON ATTACK PLANNING,

5. TYPE OF REPORT & PERIOD COVERED IN-HOUSE REPORT

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s) (10) JAMES F. MOULTON, JR

8. CONTRACT OR GRANT NUMBER(s) 627044

9. PERFORMING ORGANIZATION NAME AND ADDRESS
DEFENSE NUCLEAR AGENCY
AEROSPACE SYSTEMS DIVISION
WASHINGTON, DC 20305

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS (16) (17) A128
~~SUBTASK~~ N99QAXAA128-48

11. CONTROLLING OFFICE NAME AND ADDRESS (11)
DIRECTOR
DEFENSE NUCLEAR AGENCY
WASHINGTON, DC 20305

12. REPORT DATE 20 JANUARY 1978

13. NUMBER OF PAGES ~~26~~ (12) 27

14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*

15. SECURITY CLASS. (of this report) UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

THIS WORK SPONSORED BY THE DEFENSE NUCLEAR AGENCY UNDER RDT&E SUBTASK N99QAXAA128-48.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

FRATRICIDE
NUCLEAR DIST CLOUDS
STRATEGIC MISSILES
OPERATIONAL PLANNING CONSTRAINTS
NUCLEAR WEAPONS EFFECTS
TWO-ON-ONE TARGETING
N-ON-1 TARGETING
REENTRY VEHICLE ACCURACY
MULTI-BURST NUCLEAR EFFECTS

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

AT THE PRESENT TIME, REENTRY VEHICLE (RV) FRATRICIDE CAN BE A CONSTRAINT IN MULTI-BURST (N-ON-1) ATTACK PLANNING INVOLVING AN ARRAY OF HARD TARGETS, SUCH AS A MINUTEMAN WING. IF, HOWEVER, TOTAL ATTACK TIME, TIME ON TARGET, AND OTHER CONSTRAINTS OF AN OPERATIONAL NATURE CAN BE MET, IT WOULD APPEAR THAT RV FRATRICIDE CAN BE ELIMINATED FOR 2-ON-1 ATTACKS. WITH CONTINUED IMPROVEMENTS IN RV ACCURACY, THE CONSTRAINTS ASSOCIATED WITH MULTI-BURST ATTACK MAY ULTIMATELY BECOME INCONSEQUENTIAL.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

406762

SUMMARY

At the present time, reentry vehicle (RV) fratricide can be a constraint in multi-burst (N-on-1) attack planning involving an array of hard targets, such as a MINUTEMAN Wing. If, however, total attack time, time on target, and other constraints of an operational nature can be met, it would appear that RV fratricide can be eliminated for 2-on-1 attacks. With continued improvements in RV accuracy, the constraints associated with multi-burst attack may ultimately become inconsequential.

ACKNOWLEDGEMENT

Portions of this paper are taken, with some modification, from an earlier paper prepared by Dr. William H. Plows, Science Applications, Inc. under contract to the Defense Nuclear Agency, (DNA001-76-C-0286).

PREFACE

This report was prepared in January 1978 in response to a growing demand for a brief, unclassified discussion of the subject of strategic missile reentry vehicle (RV) fratricide. Of particular concern was how RV fratricide might place operational constraints on an attack against an array of hard targets, e.g. a field of MINUTEMAN silos. This information was provided initially only to those immediately concerned with ongoing SALT-II negotiations and the implementation of the M-X missile system. It is being given wider distribution now (June 1979) to call attention to some of the critical issues associated with RV fratricide that should not be overlooked when weighing the merits of SALT-II and other plans affecting U.S. strategic missile force structure and employment.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

REENTRY VEHICLE FRATRICIDE CONSTRAINTS ON ATTACK PLANNING

1. Background. Several articles have been published in the past 3-4 years concerned with the assessment of nuclear counterforce capabilities of the United States and the Soviet Union (Ref. 1-8). Their general theme has been that, in order to account for deficiencies in the yields and/or accuracies of individual reentry vehicles (RVs), more than one RV must be used to attack a hard target (such as a missile silo) with a sufficiently high degree of confidence to insure the "success" of a first-strike operation. In some of these articles, allusion has been made briefly to the question of interference, or fratricide, which refers to the serious degradation or total loss of effectiveness of later arriving RVs interacting with the nuclear explosion environments produced by their predecessor RVs arriving at the same or nearby targets. Generally, however, the authors have chosen to disregard the possible constraining effects that fratricide may have on attack planning and have gone on to play only the "RV numbers game."

The purpose of this paper is not to provide the detailed technical information needed to assess counterforce strategies, either on the part of the Soviet Union or the United States. Rather, it is to call attention to some of the critical issues associated with RV fratricide that should not be overlooked when entering into arms limitation negotiations with the Soviets or in the planning of strategic missile force structure and employment.

2. Fratricide Overview. A nuclear reentry vehicle (RV) targeted in space/time proximity to an earlier nuclear burst runs the risk of

encountering damaging effects that might cause mission degradation or outright failure. The mission degradation can be a result of trajectory offset (e.g., accuracy degradation), yield degradation, or incorrect fuzing. These potential RV interaction problems, taken singly or collectively, are referred to simply as fratricide. Fratricide can be a significantly constraining phenomenon for attacks on dense target complexes such as a MINUTEMAN Wing. The problem becomes increasingly complicated when individual targets in such a complex are sufficiently hard as to require more than two RVs per target to achieve desired damage expectancies. For multi-burst attacks on an isolated hard target, fratricide is somewhat less constraining.

There are a large number of potential phenomena that could be explored (Fig. 2-1). If it is recognized at the outset that one must accept the targeting constraints due to prompt radiation and blast effects and avoid these effects altogether, the remaining effects that must be considered in a fratricide assessment are primarily those associated with the threat of RV encounter with the ejecta, dust and condensate particles (e.g., ice) in the nuclear cloud. Also, to a lesser extent, the possible degradation of RV accuracy due to multi-burst blast effects must be accounted for.

When a nuclear weapon is detonated in the atmosphere, prompt radiation is absorbed in the nearby air, creating a fireball with temperatures on the order of 10^6 ^oK and pressures on the order of 10^6 kPa. These fireball gases expand and generate a blast wave which evacuates the fireball region, leaving a low density bubble. The fireball then

ENVIRONMENT	RESPONSE PHENOMENA	VEHICLE/MISSION EFFECTS
EMP/SGEMP	• HIGH VOLTAGE CURRENTS IN RV ELECTRONICS	• MALFUNCTION OR FAILURE
NUCLEAR RADIATION (n,γ)	• DOSE & DOSE RATE IN ELECTRONICS • OVERINITIATION & PREINITIATION • WARHEAD HEATING	• MALFUNCTION OR FAILURE • DEGRADED YIELD OR FAILURE • PITMELT FAILURE
FIREBALL	• RADAR FUZE RANGING • AERODYNAMICS IN LOW DENSITY	• INCORRECT BURST POINT • TUMBLING, TRAJECTORY DISPERSION
THERMAL RADIATION	• HEATSHIELD SUBSTRUCTURE HEATING	• SUBSTRUCTURE FAILURE
BLAST (SHOCK/AFTERWINDS)	• STRUCTURAL LOADS • LIFT/DRAG FORCES • ACCELEROMETER BAROMETRIC ERRORS	• FAILURE • TRAJECTORY DISPERSIONS • FUZE DEGRADATIONS
DUST/DEBRIS	• COUPLED ABLATION EROSION • PARTICLE IMPACT PENETRATION	• MASS LOSS & SHAPE CHANGE TRAJECTORY DISPERSIONS • HEATSHIELD LOSS & SUBSTRUCTURE FAILURE • SHAPE ASYMMETRIES & TRAJECTORY DISPERSIONS • VEHICLE COMPONENT FAILURE
CONDENSATE	• COUPLED ABLATION EROSION	• MASS LOSS & SHAPE CHANGE TRAJECTORY DISPERSIONS • HEATSHIELD LOSS & SUBSTRUCTURE FAILURE
EJECTA	• PARTICLE IMPACT PENETRATION	• VEHICLE/COMPONENT FAILURE

Figure 2-1 Nuclear Environments and Potential RV Fratricide Effects

rises in the atmosphere due to buoyancy, creating a large-scale vortical wind motion. If the weapon is burst on or very near the ground, a crater is formed and a significant fraction of the crater mass is ejected from the crater. The larger crater fragments follow nearly ballistic paths outward from the crater and impact within the first minute or two after burst. For both cratering and non-cratering bursts, the wind motion lofts the smaller dust and debris particles from the surface to high altitudes. In addition, because of cooling due to adiabatic expansion and mass entrainment, water vapor can condense to form ice particles. These dirt and ice particles fill the outline of the rising bubble and define the characteristic mushroom cloud. This cloud rises for several minutes and is stabilized before ten minutes after the burst. The dust, debris, and ice particles then begin to fall toward the ground. A significant mass of material remains aloft for 30 minutes or more after the burst.

A reentry vehicle encountering such a cloud is subject to several potential fratricide mechanisms. It may suffer unexpected damage to its nosetip or heatshield as a result of erosion by the particulate matter in the cloud. If the erosion is excessive, the RV may fail to perform its mission, either because of outright failure of the RV or because of accuracy degradation.

Excessive erosion can cause RV failure by removing so much heatshield material that the substructure is no longer adequately protected from the aerothermal heating loads imposed by hypersonic reentry. At high temperature, the substructure loses strength and is then subject to deformation under the normal aerodynamic loads, with consequent injury to internal components or actual RV breakup and destruction.

Excessive erosion can cause accuracy degradation by perturbing the nominal ballistic coefficient history during reentry flight. The ballistic coefficient, beta (β), may differ from its expected values through two mechanisms: 1) additional RV weight loss due to ablation alone on a flight through clear air, and 2) shape changes which change the drag of the vehicle and, if the shape changes are not axisymmetric, can also produce lift forces and torques on the RV, again causing a deviation from the planned trajectory.

Another significant particle-related fratricide mechanism is penetration of the RV body by a pebble or rock (ejecta). One consequence might be direct lethal mechanical damage to internal components. If the penetration occurs at sufficiently high altitude, other potential consequences might be a breakup of the damaged substructure under aerodynamic loads or thermal damage to internal components due to hot gases being admitted inside the RV.

Since the presence of a nuclear cloud due to the first burst at a silo would threaten the second RV targeted to that same silo, it is observed that the deleterious dust and ejecta fratricide environments could be eliminated, or at least mitigated, by having the initial burst at each silo occur at an altitude such that no crater would be generated. Even if this were done, however, some dust would be lofted by blast-wave sweep-up mechanisms and the afterwinds associated with the rising fireball. In the discussions of fratricide and laydown tactics which follow, emphasis will be given to an N-on-1 attack, where the first (N-1) RVs sent to a silo (or other hard target) will be non-cratering airbursts.

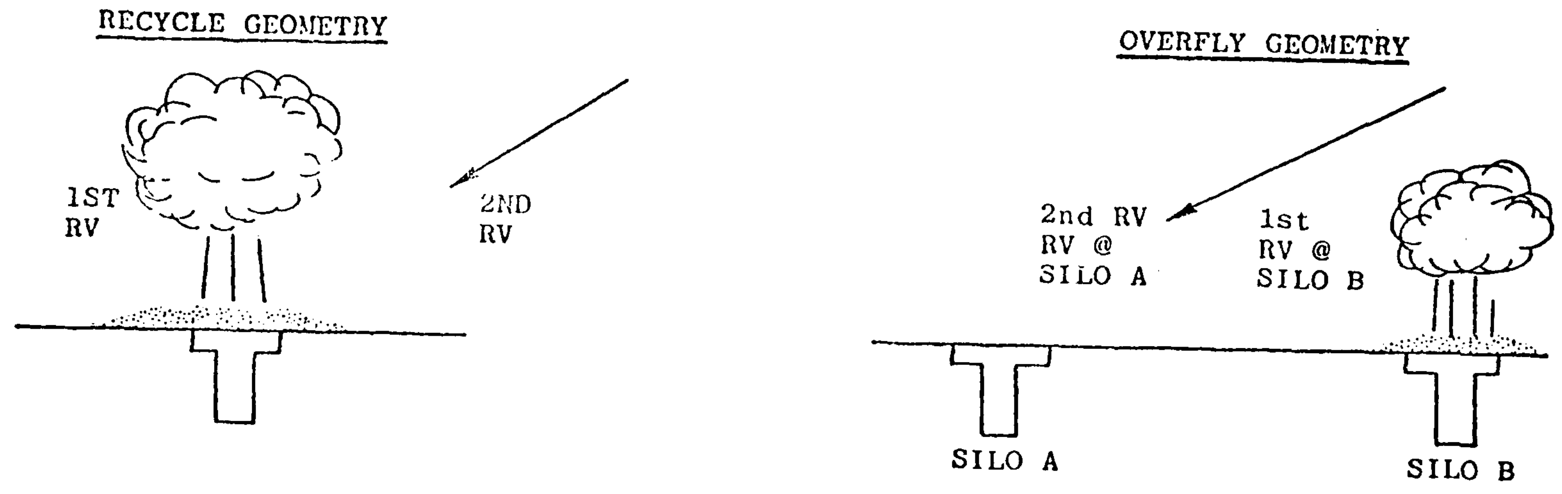
3. Fratricide Geometries and General Time Constraints:

For an attack on a hard target complex, the fratricide problem for multiple RV attacks can be discussed in terms of the problems associated with two different tactics and two basic RV impact-to-burst-point geometries. The two RV impact-to-burst-point geometries are (Fig. 3-1):

a. The overfly fratricide geometry which occurs when RVs are targeted to downrange targets relative to prior bursts. Environments of concern generally are blast and particulate clouds. The fratricide dynamics depend on environments propagation (e.g., cloud growth, shock front movement, etc.) and the RV trajectory relative to the prior bursts. Generally, the RV is at relatively high altitudes when it encounters environments of potential concern.

b. The recycle fratricide geometry occurs when multiple RVs are targeted to the same target (e.g., recycle bursts at the same target). Environments of concern generally are radiation, blast, fireball, and particulate clouds. (Ejecta must be added to this list if a cratering burst is considered.) Generally, the RV is at relatively low altitudes when it encounters environments of potential concern.

For each fratricide geometry, there are different potential time constraints for multiple RV attacks. For the recycle geometry, prompt environments (e.g., radiation, blast, fireball, etc.) define short times



Possible Tactics to Mitigate Problems (Besides Air Burst/Ground Burst)

- South to North (Intra/Inter Booster)
- Back Azimuth Selection
- Near Simultaneous 1st Bursts and 2nd Bursts Across Complex

Figure 3-1 Air Burst/Ground Burst Fratricide Geometry after the first burst near a target when subsequently arriving RVs are prohibited because of fratricide. Targeting of a subsequent RV may be denied for longer times if the first burst is a ground burst (e.g., stem, ejecta). For the overfly geometry, particulate cloud growth is a major factor defining times after burst when targets may be denied.

The relative importance of the recycle and overfly geometries depends on the attack tactics. For example, consider an attack on an ICBM complex where the attack consists of two RVs per silo. Two basic possible tactics for dense target complexes are as follows:

a. One is a basic downrange to uprange sweep across the complex. This type of attack minimizes the problems of overflying prior bursts. The tactic may be described conceptually as walking up a ladder with each rung hit twice before the next rung. The recycle geometry governs the time spacing between the two hits on each rung.

b. A near-simultaneous first wave across the whole complex, followed a short time later by another wave. The times available for RVs in the second wave are governed by both the recycle and overfly fratricide geometries. Obviously, if it is a technically possible tactic, this tactic would result in a far shorter total impact time span compared with the first tactic.

The two fratricide geometries and the two tactics described above provide a framework for the discussion of particular fratricide problems. The potential major problems associated with each geometry are summarized in Table 3-1 for the 2-on-1 attack.

Table 3-1 Major Fratricide Problems* (2-on-1)

RECYCLE GEOMETRY

ENVIRONMENT	AIR BURST FIRST	GROUND BURST FIRST
Blast	Kill/Offsets	Kill/Offsets
Ejecta	None	Kill (Penetration)
Dust/Debris Cloud	Kill (Penetration) Kill (Erosion)	Kill (Penetration) Kill (Erosion)

OVERFLY GEOMETRY

ENVIRONMENT	AIR BURST FIRST	GROUND BURST FIRST
Blast	Offsets	Offsets
Ejecta	None	None
Dust/Debris /Ice Cloud	Kill (Penetration) Kill (Erosion) Offsets (Erosion)	Kill (Penetration) Kill (Erosion) Offsets (Erosion)

* Target spacings in dense complexes such as ICBM fields are assumed.

Time constraints on targeting the second RV result because of fratricide environments which can cause the RV to fail (e.g., kill) and/or which can cause unacceptably high accuracy degradations (e.g., trajectory offsets). In the recycle geometry, the blast environment can produce high g-loadings on the RV, causing failure. Because of the winds and density changes associated with shock front propagation and the fireball dynamics, the blast-related environments might cause unacceptable accuracy degradations or trajectory offsets. The magnitude of the offsets is a strong function of the RV ballistic coefficient and the actual RV impact-to-burst-point geometry. The overfly geometry leads to the largest potential offsets. Blast kill and offsets are possible for either air burst or ground bursts.

4. Prompt Effects. Estimates have been made of the critical space/time targeting regions corresponding to outright kill of various RVs by the prompt effects of nuclear radiation and blast from cratering and non-cratering airbursts. One way of describing these fratricide results is through the concept of an exclusion footprint. A footprint associated with a prior burst is a time-dependent two-dimensional region on the ground such that, if the burst point of a subsequent RV falls within the footprint, this second RV will suffer a response to the nuclear weapon effects above some acceptable threshold (e.g., the second RV will fail, or suffer some level of accuracy degradation, etc.). Each individual nuclear effect can define its own footprints.

A footprint is a function of a number of variables: the time interval between the first burst and the arrival of the RV under consideration;

the yield and height of burst (HOB) of the prior burst; the fratricide criteria defining RV failure (e.g., excessive g-loading, neutron dose, substructure backface temperature, etc.); the RV design and trajectory parameters, etc.

It is reasonable to conclude, from a general knowledge of surface and near-surface nuclear explosions, that the exclusion footprints due to prompt effects will essentially disappear after a period of time of the order of 10 seconds for a single burst. The prompt effects from adjacent targets may or may not be of concern, depending on space/time considerations. Also, it would be expected that the corresponding keep-out times for a slower (lower β) RV would be slightly longer than for a faster (higher β) RV. Similarly, a larger yield first burst would extend keep-out times for a few seconds longer than for a smaller yield.

The preceding discussion focused on the issue of lethality in the recycle geometry. For the overfly geometry, no similar prompt effects would be expected to apply, assuming the targets in the array were adequately separated from one another.

5. Long Duration Effects. Long duration nuclear explosion effects are those which retain their potency for longer than, say, 10 seconds. Thus, most of the ejecta and the dust particles comprising the stem and head of the nuclear cloud are included in this category. As the cloud rises and cools, vapor ingested from the surrounding atmosphere will condense to form ice particles that can be roughly as erosive as dust particles. Large-scale turbulence effects due to the superposition of blast waves

from multiple sources can also degrade the accuracy of later arriving RVs. Most important to fratricide considerations, however, are the high velocity RV interactions with the particles comprising the ejecta zone or the dust stem and cloud.

A fratricide calculation requires the interweaving of constituent technology capabilities (e.g., (1) a general particle environment definition: density as a function of space/time and particle size; and (2) a general RV response model; i.e., the coupled ablation/erosion/penetration response of the heatshield/nosetip/substructure to particle impact as a function of particle densities, sizes, and impact speeds) with attributes of the RV design and reentry trajectory properties. An analysis of fratricide-related targeting constraints must face up to the uncertainties in targeting constraint estimation produced by various technology uncertainties in environment definition, response modeling, RV design assessment, RV reentry conditions and targeting tactics. A comprehensive list of uncertainties/variations might well be endless -- a finite sampling of important parameters is given in Table 5-1.

Turning to the uncertainty estimates in RV response, the erosion mass loss ratio, G, is a quantity defined to be directly proportional to the erosion rate. G is, in general, a function of particle size, the speed and angle of impact, the heatshield material, and its thermal state (e.g., virgin vs. charred). The uncertainty in G has been estimated from data scatter in single and multiple impact experiments.

An important point to be made about these statements of uncertainty is that, for the most part, it cannot be asserted with confidence that

Table 5-1 Uncertainties/Variations Affecting Fratricide

- RV Design/Reentry Conditions
  - Heatshield ablator and substructure thicknesses
  - Nosetip ablator and substructure thicknesses
  - Nosetip/heatshield materials
  - RV geometry: nose radius, base area, cone angle
  - Reentry velocity/angle (V/γ)
  - Attack azimuth
- RV Response
  - Erosion law (mass loss ratio correlation)
  - Aeroheating and ablation
  - Perforation threshold
  - Discrete (non-continuous) non-penetrating damage
- Particle Environment
  - Burst Yield/Height of Burst (HOB)
  - Airburst dust/condensate total mass loading
  - Maximum size particle lofted by an airburst
  - Particle size/shape/density distribution
  - Condensate loading as a function of ambient humidity
  - Condensate particle size distribution
  - Cloud dimensions (time history): stabilization altitude, radius
  - Multi-burst effects
  - Ambient natural weather (winds, etc.)
  - Combined dust and condensate definition

the mid-range values of many parameters are more likely to be correct than the extremes. Data scatter is compounded with modeling inadequacies and engineering judgment.

The consequences of these uncertainties in particle environment and response have been explored recently for a range of typical RVs. The conclusions reached for these RVs are as follows:

- In the recycle geometry with $10 < \Delta t < 60$ seconds:
  - For a 2-on-1 attack on a hard target, when the first burst is low enough to produce a crater, the second RV encounters the ejecta and/or stem created by the first burst with high probability (e.g., >0.75) when the double-shot damage expectancy is high. Fratricide is highly probable.
  - For a non-cratering first burst, there are no ejecta and stem encounter is non-lethal, except for worst case combinations of dust environment, RV response, and RV design.
    - Caveat: The issue of potential nosetip penetration is not yet resolved.
- In the overfly geometry with $1 < \Delta t < 10$ minutes:
  - Cloud encounter is lethal for crater-producing bursts and non-lethal for non-cratering bursts, except for worst case combinations as above.
    - Caveat on nosetip penetrations as above.
  - Shape-change and mass loss may cause large trajectory offsets in non-lethal encounters.

6. Laydown Planning Considerations:

If one assumes a missile force with the required number of RVs and range capabilities, the basic effectiveness calculation is the estimation of damage expectancy as a function of warhead yield, system delivery accuracy, target hardness, and system reliability, ignoring the possibility of fratricide at first. The next step for an N-on-1 attack might be a bounding calculation of the potential effect of dust stem fratricide on estimates of target survivability.

To discuss strike timing for an array of hard targets, assume an idealized target pattern in cross-range rows, with the downrange direction to the south. Assume inter- and intra-row target spacing is about 4-5 nmi, typical of MINUTEMAN.

The inter-wave delay on any one tier is bounded from below by the recycle geometry keep-out time. For a typical RV design, the component keep-out times are, in ascending order, due to nuclear radiation, blast kill, and fireball avoidance. (The latter effect includes the thermal radiation threat, possible flight instabilities, and possible radar ranging*.) The minimum recycle time is then the nominal keep-out time, typically including fireball avoidance, plus an allowance for effects uncertainties, plus an allowance for time-on-target uncertainties.

If a stem encounter were to be lethal, and the probability of encounter high, then the recycle time delay required might be

*The early time fireball reflects a radar signal. A simple radar fuze on a spinning RV looks at its shortest return. It might then mistake the fireball for the ground and cause premature detonation.

substantially lengthened. In marginal cases, the effect of uncertainties on the minimum recycle time could be substantial.

In the absence of any constraint on, or minimization of, the total impact span (the time from first to last burst over the entire target complex), the time between successive waves laid down on one row could be set large enough to avoid blast effects from prior waves. Alternately, and more realistically, the recycle time beyond the required minimum could be set so that blast offsets were small enough to be acceptable.

Given the specified recycle time, the individual target impact span is the interval between first and last bursts at a single target. Assuming roughly simultaneous bursts in each wave laid down on a row, an attempt can be made to minimize total impact span by overlapping the individual target impact spans between rows (i.e., planning the first burst on an uprange row before the last burst on the immediately downrange row.) This introduces the possibility of blast offsets and main cloud encounter in the overfly geometry, where both lethality and accuracy degradation can be of concern. If nominal calculations show either of these effects to be threatening, then uncertainties in environment and response can play a strong role in the assessment of attack success.

7. Conclusions:

It may be concluded from the foregoing that operational timing capabilities and "good" RV design are key to the success of a fratricide-free, 2-on-1 attack against an array of hard targets. If pre-planned timing of an otherwise well-coordinated 2-on-1 attack were to be disturbed, some measure of RV fratricide would probably result, together with a corresponding degradation in attack effectiveness. Stated another way, RV fratricide can be a constraint in attack planning; however, if total attack time, time on target, and other constraints of an operational nature can be adequately met, it would appear that RV fratricide can be eliminated for a 2-on-1 attack.

The confidence with which the above statements can be made is difficult to quantify in the statistical sense because the uncertainties in the nuclear environment and RV response predictions are not wholly random. This leads to the use of "worst case" combinations in attempts to bound fratricide assessments. If an assessment breaks down, the key issue becomes one of gauging the weight to be assigned to each "worst case" element. The problem becomes more difficult (confidence decreases) as the number of attacking RVs on each target increases. This implies that, by increasing the value of N in an N-on-1 attack plan, one should confidently expect to reach a value for which fratricide cannot be circumvented.

As long as RV yields and accuracies remain much as they are today, the need for employing more than one RV per hard target will remain in order to insure adequate damage expectancy. It is generally assumed, however, that accuracy will improve from year to year as advances are made in missile and space technology. As RV accuracy improves, the need for greater than 1-on-1 targeting will disappear -- and the potential for RV fratricide along with it.

References

1. K. Tsipis, "The Calculus of Nuclear Counterforce," Technology Review, October/November 1974.

2. E. Luttwak, "The US-USSR Nuclear Weapons Balance," Washington Papers, Vol II, No. 13, Beverly Hills: Sage Publications, 1974.

3. R. L. Leggett, "Two Legs Do Not a Centipede Make," Armed Forces JOURNAL International, Feb. 1975.

4. K. Tsipis, "Physics and Calculus of Countercity and Counterforce Nuclear Attacks," Science, Vol. 187, No. 4175, 7 Feb 1975.

5. K. Tsipis, "The Accuracy of Strategic Missiles," Scientific American, Vol. 233, No. 1, July 1975.

6. J. B. Walsh, "Strategic Arms Debate," Science, Vol. 190, pp 1117 et seq., 12 Dec 1975.

7. T. A. Brown, "Missile Accuracy and Strategic Lethality," Survival, Vol. XVIII, No. 2, March/April 1976.

8. T. J. Downey, "How to Avoid Monad - and Disaster," Foreign Policy, No. 24, Fall 1976. Reprinted in Congressional Record, Vol. 122, Sept. 20, 1976.

DISTRIBUTION LIST

DEPARTMENT OF DEFENSE

Assistant to the Secretary of Defense
Atomic Energy
ATTN: Executive Assistant

Defense Advanced Rsch. Proj. Agency
ATTN: TIO

Defense Communications Agency
ATTN: CCTC

Defense Technical Information Center
12 cy ATTN: DD

Defense Intelligence Agency
ATTN: DT-2
ATTN: DT-10
ATTN: DB-4D

Defense Nuclear Agency
ATTN: SPTD
ATTN: SPAS
ATTN: SPSS
ATTN: STSP
5 cy ATTN: TITL

Field Command
Defense Nuclear Agency
ATTN: FCTMOF
ATTN: FCTMOT
ATTN: FCTMD
ATTN: FCPR

Field Command
Defense Nuclear Agency
Livermore Division
ATTN: FCPRL

Joint Chiefs of Staff
ATTN: J-5, Force Planning & Program Div.
ATTN: J-5, Nuclear Division
ATTN: SAGA/SSD
ATTN: SAGA/SFD

Joint Strat. Tgt. Planning Staff
ATTN: JPTM
ATTN: JLTW-2

Undersecretary of Def. for Rsch. & Engrg.
ATTN: Engineering Technology, J. Persh
ATTN: Strategic & Space Systems (OS)

DEPARTMENT OF THE ARMY

BMD Advanced Technology Center
Department of the Army
ATTN: ATC-T, M. Capps

BMD Systems Command
Department of the Army
ATTN: BMDSC-H, N. Hurst

Deputy Chief of Staff for Ops. & Plans
Department of the Army
ATTN: DAMO-NCZ

DEPARTMENT OF THE ARMY (Continued)

Deputy Chief of Staff for Rsch. Dev. & Acq.
Department of the Army
ATTN: DAMA-CSS-N

Harry Diamond Laboratories
Department of the Army
ATTN: DELHD-N-TF
ATTN: DELHD-N-P, J. Gwaltney

U.S. Army Missile R&D Command
ATTN: DRDMI-TRR, B. Gibson
ATTN: DRDMI-TKP, W. Thomas
ATTN: DRDMI-XS

U.S. Army Nuclear & Chemical Agency
ATTN: Library

U.S. Army TRADOC Systems Analysis Activity
ATTN: ATAA-TDC, R. Benson

DEPARTMENT OF THE NAVY

Naval Surface Weapons Center
ATTN: Code F31
ATTN: Code K06, C. Lyons
ATTN: Code R15, J. Petes

Office of the Chief of Naval Operations
ATTN: OP 604E14, R. Blaise
ATTN: OP 604C
ATTN: OP 604C3, R. Piacesi

Strategic Systems Project Office
Department of the Navy
ATTN: NSP-272

DEPARTMENT OF THE AIR FORCE

Air Force Systems Command
ATTN: SOSS
ATTN: XRTO

Air Force Weapons Laboratory
Air Force Systems Command
ATTN: SUL
2 cy ATTN: NTO

Deputy Chief of Staff
Operations Plans and Readiness
Department of the Air Force
ATTN: AFXOOSS

Deputy Chief of Staff
Research, Development, & Acq.
Department of the Air Force
ATTN: AFRDQSM
ATTN: AFRD

Foreign Technology Division
Air Force Systems Command
ATTN: SDBS, J. Pumphrey
ATTN: TQTD
ATTN: SDBG

DEPARTMENT OF THE AIR FORCE (Continued)

Space & Missile Systems Organization
Air Force Systems Command
ATTN: DYS

Space & Missile Systems Organization
Air Force Systems Command
ATTN: MNNH
ATTN: MNNR

Space & Missile Systems Organization
Air Force Systems Command
ATTN: RST
ATTN: RSSE
ATTN: RSS

Strategic Air Command
Department of the Air Force
ATTN: XOBM
ATTN: XPFS
ATTN: DOXT
ATTN: XPQM

DEPARTMENT OF DEFENSE CONTRACTORS

Aerospace Corp.
ATTN: R. Strickler
ATTN: R. Crolius
ATTN: R. Mortensen

Analytic Services, Inc.
ATTN: J. Selig
ATTN: G. Hesselbacher

General Electric Co.
ATTN: P. Cline

General Electric Company—TEMPO
ATTN: DASIAC

Institute for Defense Analyses
ATTN: J. Bengston
ATTN: Classified Library

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Kaman Sciences Corp.
ATTN: F. Shelton

Pacific-Sierra Research Corp.
ATTN: G. Lang
ATTN: H. Brode

Prototype Development Associates, Inc.
ATTN: J. McDonald

R & D Associates
ATTN: F. Field
ATTN: C. MacDonald

Science Applications, Inc.
ATTN: J. Warner
ATTN: W. Yengst
ATTN: G. Ray
ATTN: O. Nance
ATTN: D. Hove
ATTN: W. Plows

Science Applications, Inc.
ATTN: W. Seebaugh
ATTN: W. Layson

TRW Defense & Space Sys. Group
ATTN: P. Dai
ATTN: P. Brandt
ATTN: G. Arenguren

TRW Defense & Space Sys. Group
ATTN: E. Wong
ATTN: V. Blankenship
ATTN: W. Polich

D

FI

0